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MAXIMUM LOADING OF A LINT CLEANER FOR EFFICIENT CLEANING AND OPTIMUM COTTON QUALITY

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MAXIMUM LOADING OF A LINT CLEANER FOR EFFICIENT CLEANING AND OPTIMUM COTTON QUALITY

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ABSTRACT

In a 2-year study an experimental lint cleaner with a 14-inch-diameter saw cylinder and a combing ratio of 20 was loaded with cotton at feed rates up to 100 percent above normal. The lint cleaner was tested through one stage of lint cleaning at feed rates of 0.7 to 2.1 bales per hour per foot of saw-cylinder length, saw-tip speeds of 2,932 to 5,131 ft/min, and batt densities of 0.035 to 0.075 lb/ft^2 at the feed plate. Lint-cleaner cleaning efficiency improved as batt density decreased and as saw-cylinder speed increased. However, increasing the saw-cylinder speed shifted fiber-length distribution toward the shorter fibers, decreased classer's staple length, and extracted greater amounts of lint from the bale. The differences in bale values among all saw speeds and batt densities were small and not significant. The test data indicate that about 1.6 bales (768 lb of lint) per foot of saw-cylinder length per hour can be processed with no mechanical problems. At this feed rate the lint cleaner should operate at a saw-cylinder tip speed of 4,032 ft/min, a lint-batt weight of about 0.06 lb/ft^2 at the feed plate, and a combing ratio of about 20. Test observations indicate that these recommendations can be applied to lint cleaners using other saw-cylinder diameters or combing ratios. The limiting factor on loading a lint cleaner appears to be a combination of batt density and feed rate. Some increase in the amount of cotton that commercial lint cleaners now handle appears feasible. **KEYWORDS: cotton, cotton ginning, cotton-lint cleaner, lint-cleaner loading, textile equipment.**

INTRODUCTION

The saw-cylinder lint cleaner is considered the most important ginning machinery development to make the mechanical harvesting of seed cotton feasible. Lint cleaners generally produce consistent and significant grade improvements in machine-picked cottons, usually resulting in increased market value (*3, 5, 7*).[2] Of the 3,242 gin batteries in the United States in 1975, over 99 percent had at least 1 stage of lint cleaning, 84 percent had at least 2 stages, and 20 percent had 3 or more stages (*12*).

Commercial lint cleaners used at gins are almost exclusively of the controlled-batt saw type. Lint from the gin stand or a preceding lint cleaner is formed into a batt on the condenser screen. The batt then passes through one or more sets of compression rollers and is fed onto the saw cylinder by a closely fitted feed roller and feed bar. The feed roller and bar hold the batt so that a combing action takes place as the sawteeth seize the fibers. Effective operation of

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[2] Italic numbers in parentheses refer to items in "Literature Cited" at the end of this publication.

the lint cleaner depends upon the condition of the batt, its uniformity and thickness, and the manner in which it is delivered to the saw. Cotton fed to lint cleaners at gins averages about one bale (480 pounds of lint) per foot of saw-cylinder length per hour (*9*).

Investigations in 1966 and 1967 showed that increasing the lint-cleaner combing ratio by increasing the saw-cylinder speed or decreasing the feed-roller speed significantly decreased the foreign-matter content of the lint, shifted the fiber-length distribution toward the shorter fibers, and increased the neps per 100 square inches of web. (Combing ratio is the ratio of the velocity of the surface of the combing saw to the velocity of the rim of the feed roller.) For a fixed combing ratio, faster saw speeds caused increases in lint-cleaning efficiency, shorter staple lengths, and higher nep counts in the cleaned lint. Saw-cylinder (12-inch diameter) speeds of 800 to 1,100 r/min (2,513- to 3,456-ft/min surface speed) and combing ratios of about 13 to 37 were recommended for maximum foreign-matter removal commensurate with minimum changes in fiber length. During the experiments, lint feed rate to the saw cylinder was maintained at about 0.28 bale per foot of saw-cylinder length per hour (*6*).

Other experiments in 1967 showed that two lint cleaners, operated split-stream with twice the combing ratio, produced lint with grades equivalent to those of lint processed through two lint cleaners in series at conventional operating speeds and at no significant increase in fiber damage over that caused by one lint cleaner in conventional operation (*4*). Further studies, from 1968 to 1970, indicated that lint fed to the cleaning machinery at high rates would result in decreased cleaning efficiency and perhaps lower bale values. The lint-cleaner feed rates studied ranged from 0.28 to 1.4 bales per foot of saw-cylinder length per hour. Results of these experiments showed that decreasing feed rates would give significant increases in cleaning efficiency, higher grades, and some bale-value increases, while causing no significant detrimental effect on fiber length, strength, or nep formation. With a constant lint-cleaner feed rate of 1.05 bales per foot of saw-cylinder length per hour, a lint density corresponding to a batt weight of about 0.046 lb/ft^2 at a combing ratio of 15 was recommended for efficient lint-cleaner operation and maximum return to the grower, with a practical limit of 0.060 lb/ft^2 at a combing ratio of 21 (*8*).

The efficient use of lint cleaners at gins requires that the cleaners be fed the maximum amount of cotton that they can effectively handle. A 2-year investigation, 1974 and 1975 crops, was conducted at the U.S. Cotton Ginning Research Laboratory, Stoneville, Miss., to study the effects of loading on lint-cleaner efficiency, cotton quality, and bale value when the cleaners are fed at rates up to 100 percent above normal. Previous work had been conducted at rates near or below normal. The specific objectives of the experiments, each of which consisted of only one stage of lint cleaning, were to ascertain the effects of varying the amount of cotton fed to a saw-cylinder lint cleaner on (1) the amount of foreign matter left in the cotton, (2) classer's grade and staple length, (3) fiber-length distribution, (4) number of neps in the card web, (5) bale value, and (6) amount of cotton removed from the bale as waste material. Data obtained in the studies reported here can be used in the design and operation of controlled-batt saw-cylinder lint cleaners to provide the maximum loading that will produce the optimum lint qualities desired by the grower, ginner, and spinner.

METHODOLOGY

Ginning Equipment

The seed-cotton-drying, cleaning, and ginning processes were conducted in the laboratory's commercial-size gin plant. The processing machinery sequence consisted of tower drier, six-cylinder cleaner, stick and greenleaf machine, tower drier, six-cylinder cleaner, extractor feeder, three gin stands, and an experimental lint cleaner. The lint cleaner and its settings were considered representative of current model saw-cylinder lint cleaners. An electronic moisture meter served as an aid in adjusting driers to control fiber-moisture content at ginning.

The experimental lint cleaner's feed roller (4.5-inch diameter) and saw cylinder (14-inch diameter) were operated by variable-speed electric motors, 2 and 25 hp, respectively. Saw-cylinder length was 62.5 inches, which provided 48 sawteeth per square inch of saw-cylinder surface. The setting of the feed roller to feed

bar was 0.01 inch; tension was maintained by loading springs. The spacings of the feed roller to saws and feed bar to saws were both 0.063 inch. Spacings between the five grid bars and saws were 0.031 inch at the top and 0.094 inch at the heel of the bar. A condenser drum covered with a 100- by 100-mesh screen was used to collect waste materials extracted by the experimental lint cleaner.

Test Procedure

During the processing of each experimental lot, the ambient temperature and relative humidity were recorded. The lint-cleaner saw-cylinder speed was monitored to determine whether loading the sawteeth with cotton affected cylinder speed. The packaged bales and the waste materials removed by the lint cleaner were weighed for weight-loss calculations. Samples were obtained for (1) seed-cotton moisture and foreign-matter contents before and after seed-cotton cleaning, (2) lint and cottonseed-moisture content at ginning, (3) fiber maturity, (4) lint foreign-matter content, classer's grade and staple length, fiber-length distribution analyses, strength measurements, and nep-count tests before and after lint cleaning, and (5) foreign-matter content and fiber length of lint-cleaner waste material.

Methods of Determination

The moisture content of cotton samples was determined by ovendrying, using ASTM method D 2495–70 (*1*). Seed-cotton foreign-matter levels were ascertained by the fractionation procedure, and lint foreign-matter contents were determined with the Shirley analyzer, using ASTM method D 2812–70 (*2*).

Lint-cleaner cleaning efficiency was calculated from lint foreign-matter determinations. (Cleaning efficiency is defined as the ratio of foreign matter removed from cotton to the foreign-matter content of the cotton as it enters the lint cleaner, expressed as a percentage.)

The Agricultural Marketing Service, U.S. Department of Agriculture, classed the samples at Greenwood, Miss., and made fiber tests at Clemson, S.C. Cotton length measurements were determined from Suter-Webb arrays, and strength was determined by Pressley ⅛-inch gage tests. Fiber maturity was ascertained by micronaire tests, and the neps per 100 square inches of web were counted. The nep count was based on 30 specimens totaling 1,080 square inches and was evaluated independently by 2 technicians. The webs were prepared on an accessory to the mechanical fiber blender (*11*).

Bale values for the experiments were determined from the cotton's grade and staple length, net weight, and price per pound. Bale weights were normalized to a weight of 480 pounds of lint packaged after the one stage of lint cleaning. The price per pound was based on average spot-cotton prices in 1974 and 1975 at the 10 locations designated as spot markets (*13, 14*). The average spot-market price for Strict Low Middling grade and a staple length of 34.0 thirty-seconds of an inch was 41.14 cents per pound in 1974 and 53.59 cents in 1975.

Foreign matter was separated from the lint portion of the lint-cleaner waste by the Shirley analyzer. Lint removed from the waste was tested for length distribution by the Suter-Webb array method.

The studies were analyzed as randomized complete-block experiments. Tukey's *w*-procedure was used to indicate significant differences at the 1- and 5-percent levels for individual lint-cleaner treatments (*10*).

1974 EXPERIMENT

Design

The seed cotton was grown and harvested by a local grower and was divided into 16 one-bale test lots. The variety was 'Stoneville 213', and the harvest date was October 22, 1974. The lint-cleaning treatments involved four saw-cylinder speeds and included four lint-batt densities at each speed. The experimental saw-cylinder (14-inch diameter) speeds used were 800, 1,000, 1,200, and 1,400 r/min, and the saw-surface speeds produced were 2,932, 3,665, 4,398, and 5,131 ft/min. Feed-roller speeds were such that a combing ratio of 20 was maintained on all treatments.

Batts of about equal density at each saw speed were obtained by changing the ginning rate. By increasing the number of gin stands from 1 to 3 and changing the feed rate to the stands (based on previous calibration), ginning rates of 4 to 12.2 bales per hour were selected and matched to the saw-cylinder angular veloc-

ity to maintain step increases of 25, 50, and 75 percent in the batt density.

The actual ginning rates obtained closely approximated the 16 planned ginning rates (table 1). These rates provided lint batts of increasing densities at the feed plate corresponding to average weights of 0.039, 0.050, 0.060, and 0.070 lb/ft^2 for individual batts averaged across four saw-cylinder speeds. The amount of lint delivered to the lint-cleaner saw cylinder at the various ginning rates ranged from 0.66 to 2.06 bales per foot of saw-cylinder length per hour. Lint loads on the saw cylinder averaged 0.0020, 0.0025, 0.0030, and 0.0035 lb/ft^2 of cylindrical surface for batt density treatments 1, 2, 3, and 4. These rates were almost exactly as had been expected.

The moisture content of seed cotton sampled from the wagon averaged 12.2 percent. Corresponding moisture content at the feeder apron, after passage through the seed-cotton-drying and cleaning machinery, averaged 9.6 percent. Fractionation tests of seed-cotton foreign-matter content at the wagon averaged 10.9 percent, which was reduced to 2.8 percent at the feeder apron. Cottonseed moisture content during ginning averaged 11.3 percent.

Lint sampled after ginning but before lint cleaning had an average moisture content of 5.7 percent. Moisture contents of cotton assigned to the different saw-cylinder speeds or batt-densities ranged from 4.5 to 6.9 percent. Differences in these moisture contents were not statistically significant among saw speeds or batt densities. Lint foreign-matter contents for the study averaged 7.7 percent before lint cleaning, and the lint averaged Strict Good Ordinary plus in grade. The average bale value before lint cleaning was $172.17.

Fiber tests of samples taken from ginned lint indicated the cotton to be of normal maturity. Micronaire readings for the study averaged 4.8. For the 16 treatments, upper-quartile length before lint cleaning averaged 1.17 inches, and

TABLE 1.—*Established test conditions for 1974 experiment*

Lint-cleaner saw-cylinder speed and batt No.	Ginning rate (bales/h)	Lint-cleaner feed rate[1] (bales/ft of saw cyl./h)	Actual batt density at feed plate[2] (lb times 10^{-2}/ft^2)	Lint load on saw cylinder[3] (lb times 10^{-3}/ft^2 of saw cyl.)
800 r/min:				
1	3.4	0.66	3.61	1.80
2	4.5	.86	4.72	2.35
3	5.8	1.11	6.04	3.01
4	6.9	1.32	7.23	3.60
1,000 r/min:				
1	4.6	.88	3.84	1.92
2	6.4	1.23	5.35	2.68
3	7.4	1.42	6.15	3.08
4	8.8	1.69	7.34	3.68
1,200 r/min:				
1	6.0	1.16	4.19	2.10
2	7.5	1.43	5.20	2.60
3	8.8	1.69	6.13	3.07
4	10.7	2.06	7.47	3.74
1,400 r/min:				
1	6.7	1.29	4.02	2.01
2	8.2	1.57	4.89	2.45
3	9.7	1.87	5.81	2.91
4	10.3	1.99	6.17	3.09

[1] One bale of lint is equal to 480 lb. Data represent amount of lint delivered to lint cleaner per foot of saw-cylinder length per hour.

[2] The amounts of lint used with batts 1, 2, 3, and 4 averaged 3.92, 5.04, 6.03, and 7.05 lb times 10^{-2}/ft^2.

[3] Data represent amount of lint loaded per square foot of rotating saw-cylinder surface. The amounts used with batts 1, 2, 3, and 4 averaged 1.96, 2.52, 3.02, and 3.53 lb times 10^{-3}/ft^2.

10.2 percent of the fibers were shorter than 0.50 inch.

Because of the amount of cotton required, this experiment was not replicated.

Results of Lint Cleaning

No lint-cleaner problems were encountered. However, when using the cotton batts of higher densities, the lint cleaner appeared to be loading to its capacity, as evidenced by the condenser operation (table 2). Airflow problems and some belt slippage at the condenser began to occur when the processing rate was raised to 1.69 bales per foot of saw-cylinder length per hour (table 1). However, the cleaner did operate at rates up to 2 bales per foot per hour. At the saw-cylinder speed of 1,400 r/min the noise levels and vibrations from the experimental equipment increased sharply. Loading the sawteeth with cotton reduced cylinder speed to about 2 percent below the no-load speed.

TABLE 2.—*Lint-cleaner performance when processing cotton mass, foreign-matter content after cleaning, and lint-cleaner efficiency, 1974*[1]

Saw-cylinder speed and batt No.[2]	Lint-cleaner performance[3]	Lint foreign-matter content (pct)	Lint-cleaner efficiency (pct)
800 r/min:			
1	B	4.8	32.1
2	C	5.3	37.0
3	C	4.9	13.3
4	D	5.8	32.0
1,000 r/min:			
1	B	4.0	40.4
2	B	4.6	32.5
3	C	5.7	36.4
4	E	5.3	27.1
1,200 r/min:			
1	B	4.9	29.8
2	C	4.7	40.2
3	C	6.0	32.7
4	E	5.4	38.0
1,400 r/min:			
1	A	3.6	50.2
2	C	4.3	42.3
3	E	5.0	43.3
4	D	5.2	37.2
Average	...	5.0	35.3

[1] Each foreign-matter and efficiency figure is an average for 3 samples. Differences among saw speeds are not significant for foreign-matter content of cleaned lint or lint-cleaner efficiency. Differences among lint-cleaner batt densities are significant at the 5-pct level for foreign-matter content of cleaned lint but are not significant for lint-cleaner efficiency.

[2] Batt numbers correspond to batt densities in table 1.

[3] A, Processed well, but thin batt. B, Normal operation. C, Medium to thick batt. D, Thick batt, but no problems. E, Loaded down, some condenser-air and belt problems.

Lint foreign-matter contents after lint cleaning ranged from 3.6 to 6.0 percent for the individual saw-speed and batt-density treatments (table 2). The average density for batt 1, 0.039 lb/ft^2 at the feed plate, gave the lowest foreign-matter level among the four batt densities, an average of 4.3 percent as compared with 5.4 percent for the two highest batt densities; this was statistically significant at the 5-percent level (see table 6). Foreign-matter content before and after cleaning showed that the cleaning efficiency (percent of total foreign matter removed) averaged 35.3 percent for the study (table 2). Increasing the saw-cylinder speed from 800 to 1,400 r/min, as the ginning rate increased, raised the average cleaning efficiency of batts 1 through 4 for all four speeds from 29 to 43 percent. When the batt density was increased by raising the ginning rate, a small but not significant decrease in lint-cleaning efficiency resulted.

The classer's grade after the single stage of lint cleaning ranged from Strict Good Ordinary plus to Low Middling plus (table 3). Grade-index figures for the lowest batt density were slightly higher than those for the higher densities, but these differences were not statistically significant. Differences in classer's grade among saw-cylinder speeds were small and not significant. No significant change in staple length was attributed to changes in lint-batt density. A progressive and significant decrease in length was attributed to saw-cylinder speed. The total decrease in staple length at 1,400 r/min, when compared with the length at 800 r/min, was significant at the 1-percent level (table 6).

Bale weights were lower for the higher saw-cylinder speeds, and the differences in weight between the 800- and 1,200-r/min saw speeds were significant at the 5-percent level (tables 3 and 6). Bale-weight differences among lint-batt densities were small and not significant. Bale weights varied from 476 to 486 pounds.

The one stage of lint cleaning improved the

TABLE 3.—*Classer's grade, staple length, weight, and value of ginned lint after lint cleaning, 1974*[1]

Saw-cylinder speed and batt No.[2]	Grade[3]		Staple length (32d inch)	Bale[4]	
	Index	Designation		Weight (lb)	Value
800 r/min:					
1	86.7	LM	35.7	480.8	$182.97
2	85.0	LM	35.3	481.8	182.68
3	86.7	LM	35.3	486.2	184.19
4	85.0	LM	35.0	482.0	182.68
1,000 r/min:					
1	89.7	LM+	35.0	479.3	188.01
2	86.7	LM	35.3	481.3	182.30
3	85.0	LM	35.3	477.9	181.16
4	85.0	LM	35.0	482.3	182.68
1,200 r/min:					
1	90.0	LM+	35.0	478.9	188.01
2	83.3	LM	35.0	478.2	181.16
3	85.0	LM	34.7	476.2	180.40
4	85.0	LM	35.0	478.2	181.16
1,400 r/min:					
1	88.3	LM+	34.3	479.2	187.19
2	88.3	LM+	35.0	481.5	189.18
3	82.5	SGO+	34.5	478.1	157.45
4	86.7	LM	34.0	477.5	180.12
Average	86.2	LM	35.0	480.0	181.96

[1] Each grade and staple-length figure is an average for 3 samples. Differences among saw speeds are not significant for grade index but are significant at the 1-pct level for staple length. Differences among batt densities are not significant for grade index or staple length.

[2] Batt numbers correspond to batt densities in table 1.

[3] Grade designation and corresponding grade index: LM+ =90; LM=85; SGO+ = 81; SGO=76.

[4] Weights are the amounts of lint packaged after lint cleaning. Differences among saw speeds are significant at the 5-pct level for weight per bale but are not significant for value per bale. Differences among batt densities are not significant for weight per bale or value per bale. Price per pound is based on spot cotton prices during the period August 1974 to April 1975. The average base price per pound for Strict Low Middling grade and a staple length of 34.0 thirty-seconds of an inch was 41.14 cents.

TABLE 4.—*Fiber properties and nep contents of lint samples after lint cleaning, 1974*[1]

Saw-cylinder speed and batt No.[2]	Upper-quartile length (inches)	Coefficient of length variation (pct)	Fibers longer than 1.0 inch (pct)	Fibers shorter than 0.50 inch (pct)	Fiber strength (g/tex)	Neps (No. per 100 inch² of web)
800 r/min:						
1	1.17	32.0	52.2	11.1	22.0	10.7
2	1.16	33.0	48.8	11.5	21.5	10.0
3	1.16	33.3	49.3	11.4	21.7	11.3
4	1.18	33.0	50.1	11.5	21.8	13.0
1,000 r/min:						
1	1.15	32.7	49.7	11.7	22.5	14.3
2	1.17	31.7	50.9	10.4	22.0	12.7
3	1.14	34.0	47.0	13.0	22.2	11.0
4	1.15	32.3	49.0	10.7	21.8	11.0
1,200 r/min:						
1	1.16	31.0	51.0	10.0	21.5	11.7
2	1.17	31.3	51.8	10.4	21.7	11.0
3	1.17	31.3	53.0	10.6	21.3	11.3
4	1.15	32.0	48.4	11.4	20.9	10.7
1,400 r/min:						
1	1.15	33.3	45.8	12.3	21.7	13.3
2	1.15	32.0	49.7	11.5	22.0	12.7
3	1.16	32.5	49.1	11.2	21.5	11.5
4	1.16	32.3	50.9	11.2	21.4	13.3
Average	1.16	32.4	49.6	11.2	21.7	11.8

[1] Each figure is an average for 3 samples. Tests for fiber-length distribution were performed on the Suter-Webb sorter. Differences among saw speeds and among batt densities are not significant for any of the length groupings or for nep count. Differences for fiber strength are significant at the 1-pct level among saw speeds but are not significant among batt densities.

[2] Batt numbers correspond to batt densities in table 1.

average bale value for the study by $9.79 over the cotton that received no cleaning (table 3). Although the average bale values after cleaning were slightly lower for the two highest saw speeds and batt densities, differences in values among saw speeds and among batt densities were not significant statistically.

Lint cleaning shifted the fiber-length distribution toward the shorter fibers (table 4). Upper-quartile length decreased by 0.01 inch, and the percentage of fibers shorter than 0.50 inch increased from 10.2 to 11.2 percent. Increasing the saw-cylinder speed of the lint cleaner to 1,400 r/min produced evidence of fiber shortening, probably caused by fiber breakage. Among the saw speeds tested, 1,400 r/min gave the lowest percentage of long fibers and the highest percentage of short fibers. Although the batt density of 0.05 lb/ft² generally produced longer fibers than the other batt densities, differences among all batts were small. Differences among saw speeds and among batt densities were not statistically significant for any of the fiber-length categories.

The 1,000-r/min saw speed produced a slightly higher strength cotton than the 1,200-r/min speed, and this was significant at the 1-percent level (tables 4 and 6). Although a slight decline in fiber strength occurred with an increase in batt density, differences among all densities tested were not significant.

Nep count differences attributed to saw-cylinder speed and batt densities were found to be statistically not significant (table 4). Neps after cleaning ranged from 10 to 14 per 100 square inches of web.

Extracted waste averaged 17 pounds per bale (table 5). The amount of waste material extracted was related more to saw-cylinder speed than to mass flow rate. Waste weight at 1,200

TABLE 5.—*Weight, foreign-matter content, and fiber-length distribution of waste material extracted by lint cleaner, 1974*[1]

Saw-cylinder speed and batt No.[2]	Waste weight[3] (lb/bale)	Foreign-matter content (pct)	Upper-quartile length (inches)	Coefficient of length variation (pct)	Fibers longer than 1.0 inch (pct)	Fibers shorter than 0.50 inch (pct)
800 r/min:						
1	16.2	70.0	1.06	43.7	31.1	25.5
2	15.1	68.5	1.07	39.7	33.6	20.8
3	10.7	66.5	1.11	36.3	41.1	16.3
4	14.9	69.5	1.15	34.0	46.5	13.1
1,000 r/min:						
1	17.7	61.8	1.07	42.0	34.3	22.3
2	15.6	69.0	1.09	39.7	34.9	19.5
3	19.1	67.7	1.09	39.3	36.0	19.4
4	14.6	57.9	1.10	39.0	38.3	18.9
1,200 r/min:						
1	18.1	60.3	1.10	37.3	37.3	17.5
2	18.8	62.4	1.10	41.0	38.0	20.4
3	20.9	66.9	1.11	37.0	38.6	17.1
4	18.8	61.9	1.12	35.7	42.5	15.2
1,400 r/min:						
1	17.8	58.9	1.10	38.7	38.3	19.1
2	15.4	58.6	1.10	36.7	40.2	16.5
3	19.0	57.6	1.15	33.7	47.7	12.5
4	19.6	59.0	1.11	37.3	41.7	17.6
Average	17.0	63.5	1.10	38.2	38.8	18.2

[1] Each figure is an average for 3 samples. Tests for fiber-length distribution were performed on the Suter-Webb sorter. Differences among saw speeds are significant at the 5-pct level for weight extracted per bale and foreign-matter content, and differences among batt densities are not significant for weight extracted per bale or foreign-matter content. Differences among saw speeds and among batt densities are not significant for any of the fiber-length categories.

[2] Batt numbers correspond to batt densities in table 1.

[3] Weight of waste is based on 497 lb of ginned lint packaged when using no lint cleaning.

TABLE 6.—*Significant differences among fiber properties, bale weights, and foreign-matter contents of lint and among weights and foreign-matter contents of waste material after lint cleaning, 1974*[1]

Measurement	Saw-cylinder speed and batt No.			
	800 r/min	1,000 r/min	1,200 r/min	1,400 r/min
Staple length[2] ..... 32d inch ..	35.3a	35.2ab	34.9ab	34.5b
Do[3] ..... 32d inch ..	35.3a	35.2a	34.9ab	34.5b
Bale weight[3] ..... lb ..	482.7a	480.2ab	477.9b	479.1ab
Fiber strength[2] ..... g/tex ..	21.7ab	22.1b	21.4a	21.7ab
Do[3] ..... g/tex ..	21.7ab	22.1b	21.4a	21.7ab
Waste-weight[3] ..... lb/bale ..	14.2a	16.8ab	19.2b	18.0ab
Waste foreign-matter content[3] .. pct ..	68.6a	64.1ab	62.9ab	58.5b
	Batt 1	Batt 2	Batt 3	Batt 4
Lint foreign-matter content[3] ... pct ..	4.3a	4.8ab	5.4b	5.4b

[1] Each saw-cylinder-speed treatment was tested at 4 batt densities, and each batt-density treatment was tested at 4 saw-cylinder speeds. All measurements except those for lint foreign-matter content are averages of batts 1 through 4 for each saw-cylinder speed. Measurements for lint foreign-matter content are for individual batts averaged across 4 saw-cylinder speeds.

[2] Means in a row not having a letter in common are significantly different at the 1-pct level.

[3] Means in a row not having a letter in common are significantly different at the 5-pct level.

r/min was significantly greater at the 5-percent level than the weight at 800 r/min, while differences among batt-density treatments were not significant (table 6). The amount of waste material extracted per bale by all the lint-cleaner combinations ranged from 11 to 21 pounds (table 5).

The foreign-matter content of the lint-cleaner waste averaged 63.5 percent. No significant differences in the foreign-matter content of the waste material were attributed to increasing the mass flow rate by increasing the batt density. However, increasing the flow rate while raising the saw speed from 800 to 1,400 r/min gave a consistent increase in the percentage of lint in the waste, and the total increase at 1,400 r/min was significant at the 5-percent level (table 6). The data indicated that most of the extra material removed at 1,400 r/min was lint.

Length differences in lint-cleaner waste attributed to saw-cylinder speed and lint-batt density were small and not significant (table 5). The percentage of fibers shorter than 0.50 inch was least for the highest saw speed and the heaviest batt. The waste material removed contained lint with an average upper-quartile length of 1.10 inches and an average short-fiber percentage of 18.2.

1975 EXPERIMENT

Design

This experiment was performed to replicate the more workable treatments in the 1974 experiment and to obtain additional information not covered by those data. The seed cotton, grown and harvested by a local grower, was divided into 15 one-bale test lots. The variety was 'Stoneville 213', and the harvest date was October 14, 1975. The lint-cleaning treatments involved five saw-cylinder speeds and included three lint-batt densities at each speed. The experimental saw-cylinder (14-inch diameter) speeds used were 800, 900, 1,000, 1,100, and 1,200 r/min, and the saw-surface speeds produced were 2,932, 3,299, 3,665, 4,032, and 4,398 ft/min. Feed-roller speeds were such that a combing ratio of 20 was maintained on all treatments.

Batts of about equal density at each saw speed were obtained by changing the ginning rate. By increasing the number of gin stands

from one to three and changing the feed rate to the stands, ginning rates of four to nine bales per hour were selected and matched to the saw-cylinder angular velocity to maintain lint-cleaner feed-rate step increases of 12.5, 25.0, 37.5, and 50.0 percent in the batt density.

The actual ginning rates measured ranged from 3.4 to 9.0 bales per hour, giving good control for most treatments (table 7). These rates provided lint batts with increasing densities at the feed plate corresponding to average weights of 0.037, 0.050, and 0.062 lb/ft^2 for individual batts averaged across five saw-cylinder speeds. The amount of lint delivered to the lint-cleaner saw cylinder due to ginning rates ranged from 0.65 to 1.72 bales per foot of saw-cylinder length per hour. Lint loads on the saw cylinder averaged 0.0019, 0.0025, and 0.0031 lb/ft^2 of cylindrical surface for batt density treatments 1, 2, and 3, respectively.

Moisture determinations showed that the initial seed-cotton moisture level averaged 10.7 percent for all saw-speed and batt-density treatments. Corresponding moisture content at the feeder apron, after the cotton had passed through the seed-cotton-drying and cleaning machinery, decreased to an average of 7.8 percent. The initial seed-cotton foreign-matter content averaged 12.6 percent, which was reduced by seed-cotton drying and cleaning to a level of 3.5 percent at the feeder apron. Cottonseed-moisture content during ginning averaged 11.3 percent.

Lint sampled after ginning but before lint cleaning had an average moisture content of 5.0 percent. The moisture contents of cotton assigned to the different saw-cylinder speeds and batt densities ranged from 4.1 to 6.6 percent. The moisture contents of the lint used at 800 r/min were significantly higher at the 5-percent level than the moisture contents of the lint used at the other saw speeds. There were no significant differences in the moisture contents of lint among the other saw speeds or

TABLE 7.—*Established test conditions for 1975 experiment*

Lint-cleaner saw-cylinder speed and batt No.	Ginning rate (bales/h)	Lint-cleaner feed rate[1] (bales/ft of saw cyl./h)	Actual batt density at feed plate[2] (lb times 10^{-2}/ft^2)	Lint load on saw cylinder[3] (lb times 10^{-3}/ft^2 of saw cyl.)
800 r/min:				
1	3.4	0.65	3.56	1.78
2	4.4	.85	4.65	2.32
3	5.7	1.09	5.96	2.98
900 r/min:				
1	3.7	.71	3.45	1.72
2	5.6	1.07	5.19	2.60
3	6.8	1.30	6.31	3.15
1,000 r/min:				
1	4.3	.82	3.56	1.78
2	6.1	1.17	5.11	2.56
3	7.3	1.40	6.09	3.04
1,100 r/min:				
1	5.1	.98	3.90	1.95
2	6.6	1.27	5.02	2.51
3	8.3	1.59	6.31	3.16
1,200 r/min:				
1	5.7	1.10	4.00	2.00
2	7.2	1.39	5.04	2.52
3	9.0	1.72	6.25	3.12

[1] One bale of lint is equal to 480 lb. Data represent amount of lint delivered to lint cleaner per foot of saw-cylinder length per hour.

[2] The amount of lint used with batts 1, 2, and 3 averaged 3.69, 5.00, and 6.18 lb times 10^{-2}/ft^2.

[3] Data represent the amount of lint loaded per square foot of rotating saw-cylinder surface. The amounts used with batts 1, 2, and 3 averaged 1.86, 2.50, and 3.09 lb times 10^{-3}/ft^2.

among the batt-density treatments. Lint foreign-matter contents for the study averaged 6.0 percent before lint cleaning, and the lint averaged Low Middling in grade and 34.6 thirty-seconds of an inch in staple length. The average bale value before lint cleaning was $247.42.

Fiber tests of samples taken from ginned lint indicated the cotton to be of normal maturity. Micronaire readings for the study averaged 5.0. For the 15 treatments, the fibers longer than 1.0 inch before lint cleaning averaged 59.7 percent, and the fibers shorter than 0.50 inch averaged 9.4 percent.

Results of Lint Cleaning

No lint cleaner problems were encountered at any of the speed settings for the amounts of cotton processed. However, when using the batts of the highest density, 0.062 lb/ft², the lint cleaner appeared to be loading to capacity, as evidenced by the condenser operation (table 8). This was particularly noted when ginning at the rate of 1.72 bales per foot of saw-cylinder length per hour at a saw speed of 1,200 r/min (table 7).

Lint foreign-matter contents after lint cleaning ranged from 3.2 to 4.4 percent for the individual saw-speed and batt-density treatments (table 8). The lowest batt density, 0.037 lb/ft² at the feed plate, gave the lowest foreign-matter level among the three batt densities, an average of 3.7 percent as compared with 3.9 and 4.1 percent for the two higher batt densities. The difference in foreign-matter content between the highest and lowest batt densities was significant at the 5-percent level (see table 12). Raising the saw-cylinder speed from 800 to 1,000 and 1,100 r/min decreased the average foreign-matter content of the lint from 4.4 to 3.6 and 3.7 percent, respectively. These decreases were significant at the 5-percent level. Lint-cleaner efficiency (percentage of total foreign matter removed) varied from 23 to 49 percent and averaged 34 percent (table 8). Among the three batt densities, the thickest (0.062 lb/ft²) gave the lowest cleaning efficiency. Among the saw-cylinder speeds, 1,000 and 1,100 r/min produced the highest efficiencies.

The classer's grade after the one stage of lint cleaning ranged from Low Middling to Strict Low Middling (table 9). A slightly higher grade index was obtained with the lowest batt density than with the two higher densities, but the differences were not significant statistically. Differences in classer's grade among saw-cylinder speeds were small and not significant. Although there was a slight increase in staple length during cleaning, differences attributed to saw-cylinder speed or batt density were not significant.

Among the saw-cylinder speeds, the highest average bale weight was obtained with a speed of 900 r/min. Further increases in saw speed caused a slight decrease in weight. However, changes in bale weight resulting from saw speed were small and not significant. Bale-weight differences among the three batt densi-

(*Continued on page 15.*)

TABLE 8.—*Lint-cleaner performance when processing cotton mass, foreign-matter content after cleaning, and lint-cleaner efficiency, 1975*[1]

Saw-cylinder speed and batt No.[2]	Lint-cleaner performance[3]	Lint foreign-matter content (pct)	Lint-cleaner efficiency (pct)
800 r/min:			
1	A	4.4	36.2
2	B	4.3	38.3
3	C	4.4	26.4
900 r/min:			
1	A	3.8	31.3
2	B	4.2	35.6
3	C	3.9	34.8
1,000 r/min:			
1	A	3.5	38.0
2	B	3.6	41.2
3	D	3.8	39.6
1,100 r/min:			
1	A	3.2	49.5
2	C	3.7	42.3
3	D	4.2	23.0
1,200 r/min:			
1	B	3.6	22.8
2	D	3.9	26.6
3	E	4.2	23.0
Average	...	3.9	33.9

[1] Each foreign-matter and efficiency figure is an average for 3 samples. Differences among saw speeds and among lint-cleaner batt densities are significant at the 5-pct level for foreign-matter content of cleaned lint but are not significant for lint-cleaner efficiency.

[2] Batt numbers correspond to batt densities in table 7.

[3] A, Processed well, but thin batt. B, Normal operation. C, Medium to thick batt. D, Thick batt, but no problems. E, Loaded down, some condenser air problem.

TABLE 9.—*Classer's grade, staple length, weight, and value of ginned lint after lint cleaning, 1975*[1]

Saw-cylinder speed and batt No.[2]	Grade[3]		Staple length (32d inch)	Bale[4]	
	Index	Designation		Weight (lb)	Value
800 r/min:					
1	85.0	LM	35.0	479.2	$245.06
2	86.7	LM	35.0	479.2	245.06
3	89.7	LM+	35.0	484.1	252.50
900 r/min:					
1	92.7	SLM	35.0	481.4	258.68
2	89.7	LM+	35.0	481.7	251.46
3	90.0	LM+	35.0	482.4	251.46
1,000 r/min:					
1	94.0	SLM	35.0	478.3	257.07
2	88.0	LM+	35.0	481.2	250.94
3	88.0	LM+	35.0	478.9	249.89
1,100 r/min:					
1	91.3	LM+	35.0	479.0	249.89
2	91.3	LM+	34.7	479.8	250.42
3	88.3	LM+	35.0	478.7	249.89
1,200 r/min:					
1	92.7	SLM	34.7	477.8	257.07
2	91.0	LM+	34.7	478.0	249.37
3	86.7	LM	35.0	477.9	244.54
Average	89.7	LM+	34.9	479.8	250.89

[1] Each grade and staple-length figure is an average for 3 samples. Differences among saw speeds and among batt densities are not significant for grade index or staple length.

[2] Batt numbers correspond to batt densities in table 7.

[3] Grade designation and corresponding grade index: SLM=94; LM+=90; LM=85.

[4] Weights are the amounts of lint packaged after lint cleaning. Differences among saw speeds and among batt densities are not significant for weight per bale or value per bale. Price per pound is based on spot cotton prices during the period August 1975 to April 1976. The average base price per pound for Strict Low Middling grade and a staple length of 34.0 thirty-seconds of an inch was 53.59 cents.

TABLE 10.—*Fiber properties and nep contents of lint samples after lint cleaning, 1975*[1]

Saw-cylinder speed and batt No.[2]	Upper-quartile length (inches)	Coefficient of length variation (pct)	Fibers longer than 1.0 inch (pct)	Fibers shorter than 0.50 inch (pct)	Fiber strength (g/tex)	Neps (No. per 100 inch^2 of web)
800 r/min:						
1	1.24	23.3	63.4	8.0	23.3	16.3
2	1.22	30.0	58.9	9.0	23.4	13.0
3	1.24	29.3	62.4	8.7	22.5	10.3
900 r/min:						
1	1.23	29.3	62.6	8.4	22.5	11.7
2	1.23	30.0	61.9	9.0	21.5	12.0
3	1.23	30.0	59.1	8.8	22.1	9.3
1,000 r/min:						
1	1.22	29.3	61.0	8.3	22.7	13.7
2	1.24	30.7	60.2	9.0	23.3	11.0
3	1.23	30.3	61.3	8.9	22.3	12.7
1,100 r/min:						
1	1.24	30.0	61.4	9.0	23.2	11.3
2	1.24	30.3	60.8	9.0	22.7	13.7
3	1.24	31.0	60.6	9.5	23.3	14.0
1,200 r/min:						
1	1.24	30.3	60.6	9.1	23.0	14.0
2	1.22	31.0	58.4	10.0	23.2	12.7
3	1.23	32.0	57.1	10.0	22.8	15.0
Average	1.23	29.8	60.6	9.0	22.8	12.7

[1] Each figure is an average for 3 samples. Tests for fiber-length distribution were performed on the Suter-Webb sorter. Differences among saw speeds and among batt densities are not significant for upper-quartile length, coefficient of variation, percentage of fibers longer than 1.0 inch, fiber strength, or nep count. Differences among saw speeds and among batt densities are significant at the 5-pct level for percentage of fibers shorter than 0.50 inch.

[2] Batt numbers correspond to batt densities in table 7.

TABLE 11.—*Weight, foreign-matter content, and fiber-length distribution of waste material extracted by lint cleaner, 1975*[1]

Saw-cylinder speed and batt No.[2]	Waste weight[3] (lb/bale)	Foreign-matter content (pct)	Upper-quartile length (inches)	Coefficient of length variation (pct)	Fibers longer than 1.0 inch (pct)	Fibers shorter than 0.50 inch (pct)
800 r/min:						
1	13.8	75.3	1.21	35.0	54.9	14.0
2	13.8	72.2	1.21	36.7	51.1	14.9
3	8.8	69.7	1.21	36.7	52.7	15.3
900 r/min:						
1	11.6	66.6	1.18	40.0	45.6	19.3
2	11.2	71.2	1.15	37.0	44.9	16.8
3	10.5	69.5	1.18	35.3	47.4	14.2
1,000 r/min:						
1	14.7	67.5	1.18	35.7	47.2	16.2
2	11.8	71.3	1.19	38.3	48.3	16.2
3	14.1	72.1	1.19	34.7	49.4	12.3
1,100 r/min:						
1	14.0	68.8	1.19	39.0	46.7	17.2
2	13.1	71.0	1.18	38.3	46.2	16.3
3	14.3	71.7	1.22	33.7	53.8	11.9
1,200 r/min:						
1	15.3	58.7	1.23	33.7	56.0	11.5
2	15.0	63.7	1.18	36.7	48.7	15.0
3	15.1	66.5	1.21	33.7	53.3	12.1
Average	13.1	69.0	1.19	36.3	49.7	14.9

[1] Each figure is an average for 3 samples. Tests for fiber-length distribution were performed on the Suter-Webb sorter. Differences among saw speeds are significant at the 5-pct level for foreign-matter content, upper-quartile length, and percentage of fibers longer than 1.0 inch but are not significant for weight extracted per bale, coefficient of variation, or percentage of fibers shorter than 0.50 inch. Differences among batt densities are not significant for any of the items listed.

[2] Batt numbers correspond to batt densities in table 7.

[3] Weight of waste is based on 493 lb of ginned lint packaged when using no lint cleaning.

TABLE 12.—*Significant differences among foreign-matter contents and fiber properties of lint and among foreign-matter contents and fiber properties of waste material after lint cleaning, 1975*[1]

Measurement	Saw-cylinder speed and batt No.				
	800 r/min	900 r/min	1,000 r/min	1,100 r/min	1,200 r/min
Lint foreign-matter content ..... pct ...	4.4a	3.9ab	3.6b	3.7b	3.9ab
Fibers shorter than 0.5 inch ..... pct ...	8.6a	8.7a	8.7a	9.2ab	9.7b
Waste foreign-matter content ..... pct ...	72.4a	69.1ab	70.3a	70.5a	63.0b
Waste upper-quartile length ..... inch ...	1.21a	1.17b	1.19ab	1.20ab	1.21a
Waste fibers longer than 1 inch .... pct ...	52.9a	46.0b	48.3ab	48.9ab	52.7ab

	Batt 1	Batt 2	Batt 3
Lint foreign-matter content ..... pct	3.7a	3.9ab	4.1b
Fibers shorter than 0.5 inch ..... pct	8.6a	9.2b	9.2b

[1] Means in a row not having a letter in common are significantly different at the 5-pct level. Each saw-cylinder-speed treatment was tested at 3 batt densities, and each batt-density treatment was tested at 5 saw-cylinder speeds. All measurements except those for lint foreign-matter content and fibers shorter than 0.50 inch are averages of batts 1 through 3 for each saw-cylinder speed. Measurements for lint foreign-matter content and for fibers shorter than 0.50 inch are for individual batts averaged across 5 saw-cylinder speeds.

ties were also small and not significant statistically. Bale weights ranged from 478 to 484 pounds.

The average bale value with no cleaning was increased by $3.47 with one stage of lint cleaning. Among the saw speeds, the highest bale values after cleaning were produced at 900 and 1,000 r/min. Among the lint-batt densities, the highest bale value was obtained at the lowest density, 0.037 lb/ft^2. However, differences in bale value after cleaning were not significant among saw-cylinder speeds or among batt densities.

Fiber-length distribution data show that the fibers were slightly longer after lint cleaning (table 10). In the samples after lint cleaning there was a slight shift in length distribution toward the shorter fibers as the saw-cylinder speed was increased and as batt density increased. Increasing the saw speed from 800 to 1,200 r/min increased the short-fiber content of the cotton from 8.6 to 9.7 percent, and the percentage at 1,200 r/min was significantly higher at the 5-percent level than at 1,000 r/min (table 12). Increasing the batt density from 0.037 to 0.062 lb/ft^2 slightly increased the coefficient of variation of length, but not significantly (table 10). However, the percentage of short fibers averaged 9.2 percent for the densities of 0.050 and 0.062 lb/ft^2 and 8.6 percent for the density of 0.037 lb/ft^2; these differences were significant at the 5-percent level (table 12). Increasing lint-batt density caused a slight but not significant decrease in the strength index of the cotton (table 10). Increasing the saw-cylinder speed did not significantly affect the strength index.

Nep count differences among saw speeds and among lint-batt densities were not statistically significant. Neps per 100 square inches of web after lint cleaning ranged from 9 to 16.

Extracted waste averaged 13.1 pounds per bale (table 11). The amount of waste material extracted was related more to saw-cylinder speed than to mass flow rate. However, differences in the weights of extracted waste material among saw-speeds and among batt densities were not statistically significant. The amount of waste material extracted by all the lint-cleaner combinations ranged from 9 to 15 pounds per bale.

The foreign-matter content of the lint-cleaner waste averaged 69.0 percent. No significant differences in the foreign-matter contents of the waste material were attributed to increasing the mass flow rate by increasing the batt density. However, increasing the flow rate while raising the saw speed from 800 to 1,200 r/min gave a decrease in the percentage of foreign

matter in the waste, which was significant at the 5-percent level. This indicated that the higher speeds removed a greater percentage of lint from the bale than the lower speeds did (table 12).

The extracted waste material contained lint with 14.9 percent of the fibers shorter than 0.50 inch and an average upper-quartile length of 1.19 inches (table 11). The lower percentage of short fibers occurred at 1,200 r/min, but differences among saw-cylinder speeds and lint-batt densities were small and not consistent for all length measurements.

DISCUSSION

Lint-cleaner cleaning efficiency improved as batt density decreased and as saw-cylinder speed increased. Lower batt densities slightly improved the classer's grade. Increasing the saw-cylinder speed improved cleaning but shifted the fiber-length distribution toward the shorter fibers, decreased classer's staple length, and extracted greater amounts of lint from the bale. At the higher speeds these changes were significant.

Bale values tended to be higher at saw speeds of 900 to 1,000 r/min and at batt densities of 0.037 to 0.039 lb/ft^2, the lowest densities tested. However, the differences in bale values among all saw speeds and batt densities were small and not significant.

Lint cleaners will handle up to 1.8 bales (840 pounds of lint) per foot of saw-cylinder length per hour at a saw speed of 1,200 r/min (4,398-ft/min surface speed) but with some additional fiber breakage and an increased amount of fibers extracted. Saw-cylinder speeds above 1,200 r/min are not recommended. A batt density of 0.06 lb/ft^2 at the feed plate appears to be the load limit of a lint cleaner.

Some increase in the amount of cotton that commercial lint cleaners now handle appears feasible. The 2-year study indicates that about 1.6 bales (768 pounds of lint) per foot of saw-cylinder length per hour can be processed with no mechanical problems. If this rate of feed is used, the cleaner should operate at a saw-cylinder speed of 1,100 r/min (4,032-ft/min surface speed), a lint-batt weight of about 0.06 lb/ft^2 at the feed plate, and a combing ratio of about 20.

Although the experiments were conducted on a lint cleaner using a 14-inch-diameter saw cylinder and a combing ratio of 20, test observations indicate that the recommendations can be applied to cleaners using other saw-cylinder diameters or combing ratios. In these cases, emphasis should be placed on maintaining the proper saw-tip speed and batt density at the feed plate. The limiting factor on loading a lint cleaner appears to be a combination of batt density and feed rate.

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